

UNIVERSITY OF CALIFORNIA.

AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 14.

[In order to render the results of investigations and experiments conducted by the Agricultural Department of the University of California more quickly and more generally available than has heretofore been done through the annual or biennial reports, it is proposed to embody hereafter, in the form of "Bulletins," to be issued as often as may seem desirable, reports of results, as well as such other discussions, information or answers to questions as may be of general interest. It is intended to make these bulletins, as a rule, short enough for insertion in the daily or weekly papers of the State, and proof-slips of the same will be regularly mailed to papers applying therefor. The substance of these bulletins will ultimately be embodied in a more complete and connected form, in the annual reports of the College of Agriculture.]

Examinations of Artesian Waters from the San Joaquin Valley.

In a previous bulletin (No. 7), the analysis of the water from an artesian well (Mr. Paige's), in Tulare county has been given and commented upon. It was found that while this water does not contain an unusual amount of soluble salts (11.8 grs. per gallon), the character of these salts is such, that unless corrected by the use of gypsum on the land or in the reservoir, unfavorable effects upon plant growth, due to the accumulation of carbonate of soda in the soil, would be likely to be felt before many years. This led to the investigation of waters from other wells in the Tulare artesian belt; and the results here communicated are obviously of such practical importance as to render a further and more thorough examination of the whole subject very desirable.

1. Water from a flowing well bored on the land of Mr. E. Jacobs, of Visalia, on S. 15, T. 20 S., R. 20 E., at present about $2\frac{1}{2}$ miles from the northern margin of Tulare lake. Mr. Jacobs states that in boring this well, various kinds of sands bearing inferior waters were passed through to 585 feet, where a bluish, shaly clay was struck, continuing for about 76 feet, when, on passing through, water began to overflow, discharging clean granite sand. As the sand discharge diminished, the flow gradually increased, the water rising to two inches above the mouth of the pipe. In ten days it cleared, and the well is now discharging 170,000 gallons per 24 hours.

The analysis of this water gave the following result: Total solid contents, 21.5 grains per gallon, when dried at 100° cent. Upon ignition there was a loss of 1.9 grains, consisting of organic matter and water. The remaining 19.6 grains were resolved by water into a soluble and an insoluble portion, composed as follows:

WATER OF E. JACOBS' WELL		
	Grains Per Gall.	In 100 Residue.
SOLUBLE PART.		
Carbonate of Soda.....	16.61	77.28
Sulphate of Soda.....	.67	3.19
	17.27	
INSOLUBLE PART.		
Carbonate of Lime.....	1.18	5.50
Carbonate of Magnesia.....	.63	2.94
Silica.....	.58	2.68
	2.39	
Organic Matter and Water.....	1.93	8.99
Total.....	21.00	100.58

The total of mineral contents of this water is just within the limits usually assigned to potable waters. In kind, however, the salts contained are unusual, in view of the fact that the permanently soluble portion consists almost entirely of carbonate of soda, with but a small proportion of sulphate of soda or Glauber's salt. For drinking purposes the water will be unobjectionable to most persons, the daily consumption of from 6 to 10 grains, and even more, of carbonate of soda being not an unusual thing in connection with "soda biscuits", without any sensible disturbance of health. In many soils, also, irrigation with this water might long be practiced without injurious effects. In the present case, however, the land in the neighborhood of the well is already quite heavily charged with alkali from the water of Tulare lake, as heretofore noted (see bulletin No. 7, and Rep. Coll. of Agr. for 1880, P. 22), and any increase especially of the most injurious portion—the carbonate of soda—should be carefully avoided on that account alone. Lands irrigated with this water should therefore receive, from time to time, such *dressings of land plaster* as will be sure to transform all the carbonate into comparatively inert sulphate, and so relieve the soil of at least any additional burden in the way of "black alkali".

2. The fact that some of the waters obtained in the artesian belt of Tulare are quite pure, has already been referred to in bulletin No. 7. Additional corroboration of this point is afforded by the following analysis of *waters from wells at and near Tulare City*, on what is supposed to be the eastern limit of the belt. They are described as follows by Mr. E. M. Dewey, of that place.

"The well bored for D. M. Madden is located in the town of Tulare and supplies it with water from an elevated tank into which it is pumped. It does not flow, the water rising to within six feet of the surface only. It is 220 feet in depth; boring was discontinued on ac-

count of injury to the casing.

"E. M. Dewey's flowing well is situated seven miles southwest of Tulare City, on the S. P. Railroad. It was among the largest flows at first obtained, the diameter of the stream being $3\frac{1}{2}$ ins. through a 7-inch casing; its depth is 309 feet; its flow was 860,000 gallons per day. The augur, after passing through successive strata of hard sand and clay, struck the cap rock, about 6 ins. thick, which overlies the first flow in all the wells in this vicinity. This rock is so hard that a whole day's time was consumed in drilling through it. The well at first threw up many tons of greenish sand, pebbles, bark, wood, fish-bones, etc., and what appeared to be brilliant-hued particles of abalone shells. The well is capable of irrigating 200 acres of level land, half of that amount having been irrigated during the past season, with half of the water running to waste. There are several wells in the immediate vicinity, all strongly impregnated with sulphur, and of the same force and temperature from the first flow."

Mr. Dewey also says that according to the well-borer's statement, the succession and depth of the strata penetrated is exceedingly variable within short distances. The results of the analyses are given in the following table:

TULARE ARTESIAN WATERS.

Sol. Residue, grs. per Gal.	E. M. DEWEY'S WELL.		D.M. MADDEN'S WELL.	
	9.36		5.75	
SOLUBLE PART.	Grains Per Gal	Per Ct. of Res.	Grains Per Gal	Per Ct. of Res.
Sulphate of Soda.....	1.02	10.92	.....	.....
Sulphate of Potash.....	.....	.....	.22	3.87
Carbonate of Potash.....	.....	.....	.06	1.07
Carbonate of Soda.....	2.80	29.90	2.96	51.60
Silicate of Soda.....	3.36	35.94	.....	.....
INSOLUBLE PART.				
Carbonate of Lime.....	.40	4.29	.97	16.64
Carbonate of Magnesia.....	1.19	12.71	.06	.98
Sulphate of Lime.....	.02	.27	.03	.52
Silica.....	.....	.....	.47	8.13
Organic Matter and Water	1.20	12.80	1.98	17.19
Total.....	*9.99	*106.	5.75	100.00

*The excess of these summations is due to uncertainty as to the condition of silicates and carbonates in the apportionment.

†By Difference.

It will be seen at once that not only are the totals of solid contents in these waters quite small, but that the proportion of carbonate of soda in the solid part is materially less than in the water from Mr. Jacobs' well. The water from Mr. Madden's well contains only four and three-quarter grains of actual mineral salts per gallon, and of these only 3.3 grains are permanently soluble. This is an exceptionally small amount for well water, being less even than is carried by Kern river. Mr. Dewey's water contains a larger proportion of true "alkali," yet for a well water the proportion is below the average, and both waters may be considered as being of excellent quality.

It is fairly presumable that in none of these wells the streams of water occurring nearer the surface were entirely excluded from the pipe, and as these surface waters are known to be strongly alkaline, it is more than probable that

if the deeper water alone were admitted to the flow, the waters would be found still more exempt from alkali contamination. In the case of Mr. Jacobs' well, above reported, which has been sunk to so great a depth and through a formation most probably beyond the valley sediments, it must be strongly suspected that the water of Tulare lake itself takes part in the flow, by seepage through the sandy surface strata, and through the crevices of the well casings.

It being of great interest to ascertain the character of waters flowing from unusually deep wells, Mr. Jacobs obtained and furnished for analysis a sample of the water of a well bored to the depth of 900 feet, about ten miles north of Visalia.

No exact details regarding the location of, and strata penetrated in this well have been received as yet, nor has the analysis of the water been made in full; but the following data show sufficiently its general character: Solid residue by evaporation amounts to 87.5 grains per gallon; this, on ignition, leaves 63.3 grains of mineral salts. Of this amount, water takes up 52.0 grains of permanently soluble salts, leaving behind 11.3 grains of a white powder, consisting mainly of gypsum and carbonate of magnesia with a little silica.

The permanently soluble part consists, in the main of the salts of sea-water—chlorides of calcium, magnesium and sodium—the latter, common salt, being faintly perceptible to the taste in the original water, which is slightly brackish. This water is, therefore, so totally different in character from that of the Tulare belt, that it seems likely that it is derived from an entirely different source. When mingled with such water as (e. g.) that from Mr. Jacobs' well, or with that of Tulare lake itself, it becomes milky from the formation of carbonates of lime and magnesia; and the waters so commingled would be less injurious in irrigation than either by itself.

4. It is a curious fact that the water of the well lately bored at the Stockton Asylum that is accompanied by a lively flow of gas, proves to be almost of the same composition as that last described, from the well northward of Visalia; only the Stockton water is very much stronger, as it contains nearly 200 grains of mineral substances per gallon. A more detailed report of the examination of this water and of the accompanying gas will be given in a future issue.

It is greatly to be desired that a more thorough and systematic study of this subject should enable us to circumscribe the districts within which the several kinds of water forms the artesian flow, and especially to determine whether the use of piping that will completely exclude all but the deeper streams, would not in a great degree correct the excess of carbonate of soda in the outflowing waters. The latter point is of especial interest in connection with the irrigation of lands already more or less charged with alkali; while as regards the waters charged with the salts of sea-water, the question of the health of the population is seriously involved. The presence of even small amounts of the chlorides of calcium and magnesium in the daily drinking water soon produces serious derangement of the bowels, and renders the system very much more liable to succumb to the influence of whatever

malaria may exist naturally or be produced by irrigation. When the character of such waters is known it can often be readily corrected, and the effects greatly mitigated if not entirely obviated. Many districts in the Southern States owe their reputation for ill health largely if not chiefly to the daily use of just such waters, and its abandonment has promptly relieved the diffi-

culty.

No such easily avoidable obstacles should, assuredly, be allowed to detract from the full realization of the advantages which the discovery and development of the artesian belt places within reach of the inhabitants of the San Joaquin valley.

E. W. HILGARD.

Berkeley, Aug. 20, 1884.